

# Effect of Processing Unripe Plantain (*Musa paradisiaca*) Extracts on Some Biochemical Parameters in Alloxan-Induced Wistar Rats

## ABSTRACT



Unripe plantain is used for management of diabetes mellitus in Nigeria, the possible effect of its methods of processing on some biochemical parameters has not been investigated. The objective of this study is to determine the effect of methods of processing unripe plantain on blood glucose, Total Cholesterol, Triglyceride, HDL, LDL, serum Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Alanine Phosphatase (ALP), total protein, albumin, creatinine, uric acid and urea levels in alloxan-induced diabetic rat models. Twenty male albino wistar rats were used and were divided into 5 groups of 4 rats each. Group 1 (normal control) received standard rat feeds; group 2 (diabetic control) received standard rat feeds; groups 3,4 and 5 received boiled, roasted and dried unripe plantain pellets respectively. In the result, a significant ( $P<0.05$ ) difference was observed as fasting blood glucose levels were reduced for those experimental animals administered dried, boiled and roasted extracts respectively. Triacylglycerol levels were significantly decreased ( $p<0.05$ ) for those diabetic rats administered dried, boiled and roasted extracts respectively. The Total cholesterol levels were significantly decreased ( $p<0.05$ ) for those administered dried, roasted and boiled extracts respectively. The LDL-cholesterol levels were also significantly decreased ( $p<0.05$ ) for those treated with dried, roasted and boiled extracts respectively. The HDL-cholesterol were significantly increased for the diabetic administered dried extract, roasted extract and a significant decrease for those administered boiled extract. There were significant increase ( $p<0.05$ ) in the levels of serum ALT, AST and ALP in the diabetic control group compared to the normal control group. On administration of unripe plantain, the values of these enzymes significantly ( $p<0.05$ ) decreased. The boiled extract showed a greater decrease in the level of ALT and ALP whereas the dried extract showed a greater decrease in the level of AST. There were also increase in the level of urea and uric acid in the diabetic control compared to the normal control group. However, administration of unripe plantain drastically reduced their levels. The dried extract showed a greater decrease in the levels of both urea and uric acid. The creatinine level is seen to increase in the diabetic control group when compared to the normal control group and showed greater increase on administration of unripe plantain, with the group fed with roasted extract having the highest level of creatinine. Therefore, unripe plantain can be used to ameliorate the effect of renal and hepatic dysfunction caused by diabetes irrespective of the processing method. However, the boiled method of processing shows greater ability in the management of hepatic dysfunction while the dried extract shows greater ability to ameliorate the complications of diabetic renal dysfunction.

**Keywords:** Diabetes Mellitus, Unripe Plantain, Alloxan

## INTRODUCTION

One of the most challenging diseases of the 21st century is Diabetes. Diabetes mellitus is a metabolic disease characterized by hyperglycemia, resulting from partial or total destruction of pancreatic beta

40 cells (Shepherd, 2005). It affects the essential biochemical pathways of the body (carbohydrate,  
41 protein and lipid metabolism) and its prevalence is rising globally, which includes the rural Nigeria  
42 populations (Ime *et al.*, 2011; Karau *et al.*, 2012). Due to the inability of the modern therapy to  
43 control all the patho-physiological aspects of the disorder, as well as the enormous cost it poses on  
44 the economy of the developing nations of the World, alternative strategies are urgently needed  
45 (WHO, 2002).

46 The global concern for the diversification of the uses of plant foods to improve normal and  
47 therapeutic nutrition for diabetes control has shifted scientists' interest to enhancing the potential  
48 sources of beneficial constituents in plant foods. Plant foods have generated increasing research  
49 interest because of their anti-diabetic potentials. The diets/medicinal plants that are commonly used  
50 in the management of diabetes in Nigeria include: acha (*Digitaria exillis*), breadfruit (*Treculia*  
51 *Africana*) and beans (*Phaseolus vulgaris*) (WHO, 2003). However, diabetic patients have often  
52 complained of the monotony of staying on a particular diet (personal communication) and this has  
53 therefore increased the research into other plants.

54 Plantain (*Musa paradisiaca*) belongs to the *musacae* family and it is cultivated in many tropical and  
55 sub-tropical countries of the world. Plantain is a source of starchy staple for millions of people in  
56 Nigeria. It contains low quantities of minerals and sugars; this can be seen in an unripe plantain.  
57 Scientifically, unripe plantain has being documented as a hypoglycemic plant (Nelson *et al.*, 2006). In  
58 folklore medicine, unripe plantain is used in the management of diabetes, renal and liver dysfunction  
59 (Iweala *et al.*, 2001). Although, unripe plantain is used to manage diabetes mellitus in Nigeria, the  
60 possible effect of its methods of processing on some biochemical parameters, including renal and  
61 hepatic dysfunction has not been investigated. This study was aimed at examining the effect of  
62 methods of processing unripe plantain on some biochemical parameters in alloxan-induced diabetic  
63 rats.

## 64 **MATERIALS AND METHODS**

### 65 **Preparation of Plant Materials**

66 Matured freshly cut unripe green plantain (*Musa paradisiacal*) where purchased from a local market  
67 in Jos Plateau state, Nigeria. The bunch of *Musa paradisiacal* was rinsed with water to remove latex  
68 and dirt. These were divided into three portions and prepared differently. To the first portion, it was  
69 boiled in boiling water for 30 minutes, allowed to cool before being peeled and cut into pieces, air-  
70 dried at room temperature for 6-7 days. The dried pieces were pulverized using a milling machine to  
71 obtain a fine powder. The second portion was roasted using a charcoal oven until it is browned. It  
72 was peeled, cut into piece pulverized using a milling machine to obtained a fine powder. The last  
73 portion was air-dried at room temperature for 6-7 days. The dried plant food was milled into  
74 powder.

### 75 **Extraction of Plant Materials**

76 Each of the processed plantain powder was used for the extraction process. 100g of each powdered  
77 plant material was weighed using a weighing balance and transferred into different beakers. Each  
78 was dissolved with 1L of distilled water and allowed to stay for twenty four hour for maximum  
79 extraction of the active ingredient(s). The dissolved plant was filtered and the filtrate was kept in an  
80 oven at 60°C. This was done to ensure that it undergo evaporation until it becomes dried. The dried  
81 extracts were separately transferred into air- tight containers and stored in the refrigerator.

**82 Experimental Animals**

83 The experimental animals used were twenty (20) healthy Wistar rats (weighing 185-200kg) obtained  
84 from the animal house of University of Jos, Nigeria. They were allowed to acclimatize for 2 weeks,  
85 after which they were maintained under a constant 12 hours light and dark cycle and at room  
86 temperature.

87

**88 Induction of Experimental Animals**

89 The animals were induced with freshly prepared saline solution of Alloxan and injected into the  
90 animals intraperitoneally. After 48 hours of induction of Alloxan, the animals were tested to confirm  
91 if they were diabetic.

92

**93 Grouping and Administration of Extract**

94 The plant (plantain extract) from the differently processed method were administered orally to the  
95 animals with 150ml/kg body weight measurement. This was given to the experimental animals  
96 (albino rats) that were divided into 5 groups of 4 each as follows:

97 Group 1: normal rats administered standard feed pellets (Normal control)

98 Group 2: diabetic control rats administered standard feed pellets (Diabetic control)

99 Group 3: diabetic rats administered boiled plantain extract

100 Group 4: diabetic rats administered roasted plantain extract

101 Group 5: diabetic rats administered dried plantain extract.

102 The extract was administered for the period of 8 days following an interval of 48 hours fasting  
103 period. The administration was stopped at the eighth day, the rats were anesthetized with  
104 chloroform and their blood samples collected.

105 Ethical issues were observed in line with the regulations of animal usage and approval was  
106 obtained as required in the University of Jos ethical committee guide.

107

**108 METHODS****109 Determination of Glucose**

110 Glucose reacts with O'toluidine in a glacial acetic acid with heat of field N-glucosyl amine which is  
111 blue green in color. The absorbance is measured at 025nm (Bishop *et al.*, 2000).

**112 Determination of Cholesterol Level**

113 The Total Cholesterol was determined by Liebermann Burchard's method (Edward and Morris,  
114 1969).

**115 Determination of Creatinine**

116 Creatinine reacts with picric acid to produce a coloured compound creatinine atanine picrate which  
117 was photometrically measured. The intensity of the colour is a function of the creatinine in the  
118 blood. The serum total proteins, albumin, uric acid and urea were determined using Biosystems  
119 Diagnostic kits as described by (Tietz, 1995; Friedman and Young, 2001).

**120 Determination of Serum Urea**

121 The ammonia reacts with phenol in the presence of hypochlorite to form indophenols which give a  
122 blue compound in alkaline solution (Bolleter *et al.*, 1961).

**123 Hematological Analysis**

124 The hematological analysis carried out were Packed Cell Volume, hemoglobin, platelet count, white  
125 blood cell count, red blood cell count, using standard procedures (Saeed *et al.*, 2011).

126

127 **STATISTICAL ANALYSIS**

128 Data was subjected to analysis using the Statistical Package for Social Sciences (SPSS), version 15.0.  
 129 Results were presented as the means standard deviations of triplicate experiments. One way  
 130 analysis of variance (ANOVA) was used for comparison of the means. Differences between means  
 131 were considered to be significant at P <0.05 using the Duncan Multiple Range Test.

132 **RESULTS**

133 The administration of alloxan at a dosage of 65mg/kg body weight to the rats produced a stable  
 134 diabetic condition within few days in most of the experimental rats. Administration of unripe  
 135 plantain resulted in 510%, 55% and 113% decrease in blood glucose compared to the diabetic  
 136 control in the groups administered boiled, roasted and dried extracts respectively (table 1).

137 **Table 1: Result of Effect of Plantain Extracts on Blood Glucose Level (mMol/L) in Diabetic Rat**  
 138 **Models**

Treatment Groups		Boiled Extract	Roasted Extract	Dried Extract
<b>A</b>	<b>Normal Control</b>	5.56±0.01	5.56±0.01	5.56±0.01
<b>B</b>	<b>Diabetic Control</b>	19.84±0.02 <sup>a</sup>	19.84±0.02 <sup>a</sup>	19.84±0.02 <sup>a</sup>
<b>C</b>	<b>Diabetic Treated</b>	3.25±0.02 <sup>ab</sup>	12.82±0.02 <sup>ab</sup>	9.32±0.02 <sup>ab</sup>

139 Values are expressed as mean ± SD, n = 4 for each group.

140 <sup>a</sup> values are significantly different from normal control group (P<0.05)

141 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

142

143 **Table 2: Result of Effect of Plantain Extracts on Lipid Profile Concentrations in Diabetic Rat Models**

Treatment Groups		TG	TC	LDL	HDL
<b>A</b>	<b>Normal control</b>	1.37±0.02	3.68±0.01	2.26±0.36	1.54±0.02
<b>B</b>	<b>Diabetic control</b>	2.53±0.18 <sup>a</sup>	5.84±0.01 <sup>a</sup>	3.24±0.01 <sup>a</sup>	0.47±0.01 <sup>a</sup>
<b>C</b>	<b>Diabetic + boiled extract</b>	1.73±0.01 <sup>ab</sup>	4.43±0.01 <sup>ab</sup>	2.61±0.01 <sup>ab</sup>	0.08±0.01 <sup>ab</sup>
<b>D</b>	<b>Diabetic + roasted extract</b>	1.89±0.01 <sup>ab</sup>	4.82±0.01 <sup>ab</sup>	2.93±0.02 <sup>ab</sup>	0.74±0.02 <sup>ab</sup>
<b>E</b>	<b>Diabetic + dried extract</b>	1.53±0.01 <sup>ab</sup>	4.02±0.01 <sup>ab</sup>	2.24±0,02 <sup>ab</sup>	0.94±0.01 <sup>ab</sup>

144 Values are expressed as mean ± SD, n = 4 for each group.

145 <sup>a</sup> values are significantly different from normal control group (P<0.05)

146 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

147

148 **Table 3: Result of Effect of Plantain Extracts on Enzymes of Rat Models**

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Treatment Groups		ALT(mmol/L)	AST (mmol/L)	ALP (mmol/L)
<b>A</b>	<b>Normal Control</b>	11.31±0.01	16.84±0.02	236.62±0.02
<b>B</b>	<b>Diabetic Control</b>	48.18±2.46 <sup>a</sup>	79.87±0.01 <sup>a</sup>	642.24±0.01 <sup>a</sup>
<b>C</b>	<b>Diabetic + boiled extract</b>	31.46±0.01 <sup>ab</sup>	60.16 ±0.09 <sup>ab</sup>	86.00±0.70 <sup>ab</sup>
<b>D</b>	<b>Diabetic + roasted extract</b>	39.85±0.03 <sup>ab</sup>	64.41 ±0.01 <sup>ab</sup>	431.00±0.70 <sup>ab</sup>
<b>E</b>	<b>Diabetic + dried extract</b>	36.36±0.02 <sup>ab</sup>	49.42 ±0.01 <sup>ab</sup>	411.00± 0.01 <sup>ab</sup>

150 Values are expressed as mean ± SD, n= 4 for each group.

151 <sup>a</sup> values are significantly different from normal control group (P<0.05)

152 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

153

154 **Table 4: Result of Effect of Plantain Extracts on Creatinine, Urea and Uric Levels in the**

155 **Experimental Rat Models**

Treatment Groups		Creatinine (mmol/L)	Urea (mmol/L)	Uric acid (mmol/L)
<b>A</b>	<b>Normal Control</b>	91.54±0.01	7.02 ± 0.01	226.08±0.01
<b>B</b>	<b>Diabetic Control</b>	173.97±1.01 <sup>a</sup>	22.82 ± 0.01 <sup>a</sup>	564.24±0.02 <sup>a</sup>
<b>C</b>	<b>Diabetic + Boiled Extract</b>	182.54 ±0.02 <sup>ab</sup>	10.42±0.01 <sup>ab</sup>	396.04± 0.01 <sup>ab</sup>
<b>D</b>	<b>Diabetic + Roasted Extract</b>	194.64 ±0.02 <sup>ab</sup>	12.82±0.02 <sup>ab</sup>	401.64± 0.01 <sup>ab</sup>
<b>E</b>	<b>Diabetic + Dried Extract</b>	177.54±0.01 <sup>ab</sup>	9.32±0.02 <sup>ab</sup>	371.84± 0.01 <sup>ab</sup>

156 Values are expressed as mean ± SD, n= 4 for each group.

157 <sup>a</sup> values are significantly different from normal control group (P<0.05)

158 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

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164 **Table 5: Result of Effect of Plantain Extracts on the Total Protein and Albumin Concentrations in**  
 165 **Rat Models**

Treatment Groups		Total protein g/L	Albumin g/L
<b>A</b>	<b>Normal Control</b>	75.60±0.01	35.62±0.02
<b>B</b>	<b>Diabetic Control</b>	68.42±0.02 <sup>a</sup>	28.47±0.02 <sup>a</sup>
<b>C</b>	<b>Diabetic + Boiled Extract</b>	72.08±0.01 <sup>ab</sup>	32.34±0.04 <sup>ab</sup>
<b>D</b>	<b>Diabetic + Roasted Extract</b>	70.38±0.01 <sup>ab</sup>	30.30±0.01 <sup>ab</sup>
<b>E</b>	<b>Diabetic + Dried Extract</b>	74.04±0.01 <sup>ab</sup>	33.18±0.01 <sup>ab</sup>

166 Values are expressed as mean ± SD, n= 4 for each group.

167 <sup>a</sup> values are significantly different from normal control group (P<0.05)

168 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

169

170 **Table 6: Result of Effect of Plantain Extracts on some Hematological Parameters in Diabetic Rat**  
 171 **Models**

Treatment Groups	PCV	HB	WBC	PLT	RBC
<b>Normal Control</b>	32.00±0.81	7.62±0.01	5260±1.63	242000±0.81	5360±201.33
<b>Diabetic Control</b>	30.00±0.81 <sup>a</sup>	3.24±0.01 <sup>a</sup>	9500.00±0.8 <sup>a</sup>	318000.00±163 <sup>a</sup>	9525.00±49.33 <sup>ab</sup>
<b>Diabetic + Boiled Extract</b>	35.00±0.81 <sup>ab</sup>	8.32±0.01 <sup>ab</sup>	7400.00±0.81 <sup>ab</sup>	26400±0.81 <sup>ab</sup>	4898.00±0.81 <sup>ab</sup>
<b>Diabetic + Roasted Extract</b>	33.00±2.94 <sup>ab</sup>	4.51±0.01 <sup>ab</sup>	7450.00±0.00 <sup>ab</sup>	26600±3.26 <sup>ab</sup>	7500±1.41 <sup>ab</sup>
<b>Diabetic + Dried Extract</b>	35.00±2.89 <sup>ab</sup>	5.31±0.01 <sup>ab</sup>	6600±0.00 <sup>ab</sup>	255000±0.81 <sup>ab</sup>	6600.00±0.81 <sup>ab</sup>

172 Values are expressed as mean ± SD, n= 4 for each group.

173 <sup>a</sup> values are significantly different from normal control group (P<0.05)

174 <sup>b</sup> values are significantly different from diabetic control group (P<0.05)

175

176 The serum Alanine aminotransferase, Aspartate aminotransferase and Alanine phosphatase enzyme  
 177 levels of the diabetic control were significantly increased (p<0.05) compared to the non-diabetic  
 178 control group. Administration of unripe plantain extracts significantly decreased (p<0.05) the levels

179 of these enzymes, especially in the group fed boiled extract (31.46mmol/L) followed by the group  
180 fed dried extract (36.36mmol/L) and then the group fed roasted extract (39.85mmol/L) for ALT. For  
181 AST, the level of decrease is more in the group fed dried extract (49.42mmol/L) as against the boiled  
182 (60.16mmol/L) and roasted (63.41mmol/L) plantain extracts respectively. There is similar decrease in  
183 ALP in the trend 86mmol/L for boiled, 411mmol/L for dried and 431mmol/L for roasted plantain  
184 extract respectively (table 3).

185 There is significant increase in creatinine level in the diabetic control group compared to the non-  
186 diabetic control group. On administration of unripe plantain extracts, there were significant  
187 increases ( $p<0.05$ ) especially in the group administered roasted extract (194.64mmol/L). Also, there  
188 is significant increase in the level of urea in the diabetic control group compared to the non-diabetic  
189 control group. However, on administration of unripe plantain, significant decrease ( $p<0.05$ ) was  
190 observed as follows: 9.32mmol/L, 10.42mmol/L and 12.82mmol/L for groups fed dried, boiled and  
191 roasted extracts respectively. A significant increase is observed in the level of uric acid in the diabetic  
192 control group (564.24 mmol/L) compared to the non-diabetic group (226.08 mmol/L). After  
193 treatment with unripe plantain extracts, uric acid level decreased significantly to 396.04 mmol/L,  
194 401.64mmol/L and 371.84mmol/L for the groups treated with boiled, roasted and dried extracts  
195 respectively.

196 A significant decrease was observed in the level of total protein in the diabetic control group  
197 (68.42g/L) compared with the non-diabetic control group (75.60g/L). After administration of unripe  
198 plantain extracts, there was observable significant increase ( $p<0.05$ ) especially in the group  
199 administered dried extract (74.04g/L) followed by boiled extract (72.08g/L) and then the group  
200 administered roasted extract (70.38g/L). Similarly, there is significant decrease of Albumin level in  
201 the diabetic control (28.47g/L) compared with the non-diabetic control (35.62g/L). Administration of  
202 unripe plantain significantly increase ( $p<0.05$ ) this value to 32.34g/L, 30.30g/L and 33.18g/L for  
203 groups treated with boiled, roasted and dried plantain extracts respectively.  
204

## 205 **DISCUSSION**

206 Different factors can affect or influence blood glucose level. These include the physical form of the  
207 food, degree and type of processing example, cooking method and time, amount of heat and  
208 moisture used (Pi-sunyer, 2002), and also the type of starch (amylase versus amylopectin). Findings  
209 from this study indicate that the boiled plantain extract has the highest hypoglycemic effect while  
210 the roasted extract has the least; thus confirming the ability of unripe plantain to ameliorate  
211 hyperglycemia. This further explains that the effect of moist heating improves the ability of the food  
212 substance to ameliorate the effect of hyperglycemia than drying without direct heating (drying) and  
213 dry heating (roasting). Boiling of the plantain allowed the starch granules to swell, gelatinize and  
214 increase the availability of amylase digestion and thereby increasing starch availability (Bahado *et*  
215 *al.*, 2006).

216 Serum total cholesterol, LDL cholesterol and Triglyceride levels of the diabetic control rats are  
217 significantly ( $p<0.05$ ) higher than that of the non-diabetic control rats with decreased level of HDL-  
218 Cholesterol (table 2). This is an indication that diabetes mellitus is associated with elevated levels of  
219 Total cholesterol, LDL-Cholesterol and Triglyceride with decreased level of HDL-Cholesterol. The

220 result shown in the table also indicates that the diabetic animals when fed with unripe plantain have  
221 significant ( $p < 0.05$ ) decrease in the levels of cholesterol compared with the controls. This is an  
222 indication that plantain however reduces cholesterol (Gould *et al.*, 1998). Increase in cholesterol is a  
223 risk factor associated with arteriosclerosis and cardiovascular diseases (Cooper *et al.*, 2007). The  
224 experimental group fed with dried plantain extract had the most pronounced effect in lowering  
225 serum cholesterol level while the roasted plantain extract had the least. Therefore, dried plantain  
226 extract has the greatest ability to ameliorate the effect of arteriosclerosis and cardiovascular disease  
227 than the boiled and the roasted extracts. From the same table, triglyceride and Low density lipid  
228 (LDL) concentrations are significantly decreased ( $p < 0.05$ ) in all the diabetic treated groups, with the  
229 group treated with dried extract being the most decreased. High levels of LDL-Cholesterol and  
230 triglyceride have been associated with heart disease (Nikkila, 1984). In the medical term, high  
231 cholesterol and triglyceride levels are referred to as lipid disorder, which increases the risk of  
232 atherosclerosis and also heart disease, stroke and high blood pressure (Cooper *et al.*, 2007). The  
233 consumption of unripe plantain has been shown to reduce triglyceride level (Kaimal *et al.*, 2010).

234 Measurement of enzymatic activities of aminotransferases (AST and ALT) and phosphatases is of  
235 clinical and toxicological importance as changes in their activities are indicative of tissue damage by  
236 toxicants or in disease conditions (Tietz, 1995; Radhika *et al.*, 2012; Adesokan *et al.*, 2009).  
237 Aminotransferases such as ALT and AST and ALP are common liver enzymes whose activities are  
238 sensitive indicator of liver cell injury and are helpful in recognizing hepatocellular diseases such as  
239 diabetes. In Harris *et al.*, (2005) studies, it was shown that individuals with type 2 diabetes mellitus  
240 (T2DM) have a higher incidence of liver function abnormalities than individuals who do not suffer  
241 from diabetes mellitus. This study indicates an increase in the level of the diagnostic enzymes (AST,  
242 ALT and ALP) in the serum of alloxan diabetic rat models which is attributable to the toxicity of  
243 alloxan to the tissue that express GLUT2 transporter such as hepatocytes and renal tubular cells  
244 (Eleazu *et al.*, 2013). The effect of alloxan on the levels of these diagnostic enzymes (AST, ALT and  
245 ALP) in the serum of alloxan diabetic rat models has remained unraveled. While some authors  
246 reported increased activities of AST, ALT (Rajesh, 2012) and ALP (Umesh *et al.*, 2004) in the liver of  
247 alloxan diabetic rat models, some others reported no alteration in the levels of these enzymes in the  
248 serum of the diabetic rats. The increase observed in the level of these enzymes in the serum of the  
249 diabetic control rat models could be as a result of leakage of these enzymes from the liver cytosol  
250 into the blood stream (Navarro *et al.*, 1993) which gives an indication of the hepatotoxicity of  
251 alloxan. However, Treatment of the diabetic animals with unripe plantain was able to significantly  
252 decrease ( $p < 0.05$ ) the levels of these enzymes in the serum of these rat models indicating the ability  
253 of unripe plantain to repair liver damage. The boiled plantain extract has the highest ability to  
254 decrease the levels of AST and ALP, while the dried extract has the greatest ability to decrease the  
255 activity of ALT.

256 It is the function of the kidney to remove urea from the blood. In kidney impairment, the urea level  
257 builds up in the blood because the kidneys are unable to clear the urea from the blood stream  
258 (Okechukwu *et al.*, 2013). In this study, the serum urea levels of the diabetic control group increased  
259 significantly ( $p < 0.05$ ) compared with the non-diabetic control. This could be as a result of kidney  
260 impairment in diabetic control rats. However, treatment of the diabetic animals with unripe plantain  
261 resulted to significant decrease ( $p < 0.05$ ) of urea in the serum of the diabetic rats (table 4). This  
262 shows that plantain may possess protective effects on the kidney. The dried unripe plantain has the



263 most effective ability to ameliorate the effect of urea on the kidneys of the diabetic animals while  
264 the roasted plantain extract has the least effect.

265 Creatinine, a metabolite of creatine is generated from muscle and excreted by the kidney. However,  
266 in kidney impairment, creatinine is poorly cleared and therefore builds up in the blood (Okechukwu  
267 *et al.*, 2013). The outcome of this study significantly highlighted that consumption of unripe plantain  
268 (be it boiled, roasted or dried) as seen in table 4, can induce an elevation of creatinine level, which  
269 by implication, suggests that unripe plantain has a higher propensity to induce renal failure due to  
270 increase in creatinine level. The diabetic rats treated with roasted plantain extract have the highest  
271 level of creatinine, while those treated with the dried extract has the least.

272 The uric acid level of the diabetic control group is higher when compared to the non-diabetic group.  
273 This could be as a result of renal failure, resulting to poor clearance of uric acid by the kidney, since it  
274 is the function of the kidney to clear out uric acid from the blood. High levels of uric acid can lead to  
275 kidney stone or cause solid crystals to form within joints. This causes a painful condition called gout.  
276 If gout remains untreated, these uric acid crystals can build up in the joint or nearby tissues, forming  
277 hardy lumpy deposit called tophi. On administration of unripe plantain, the levels of uric acid  
278 significantly decrease ( $p < 0.05$ ). This could be as a result of the renal protective effect of unripe  
279 plantain. Precisely, the dried plantain extract has the highest uric acid-reducing ability while the  
280 roasted extract has the least.

281 The decrease in the serum protein of the diabetic control rats is an indication of proteinuria which is  
282 an important clinical marker of diabetics nephropathy and this decrease can be attributed to  
283 increase protein catabolism while the increase in the serum protein level of the diabetic rats fed  
284 unripe plantain extracts is an indication of the protective action of unripe plantain against  
285 nephrotoxicity (Jefferson *et al.*, 1983) and also unripe plantain is a good source of protein (Foy and  
286 Parratt, 1960). The study shows that the dried plantain extract has the highest ability to ameliorate  
287 the effect of nephropathy in the diabetic rats.

288 The low serum albumin level of the diabetic control rats could be attributed to their low serum  
289 protein levels suggesting impaired renal function for the rats of this group or it may also suggest  
290 impaired liver function for this group. The elevation of the serum albumin levels of the diabetic rats  
291 fed unripe plantain suggests that plantain can be used in the management of diabetic renal  
292 dysfunction. However, the dried plantain extract suggests better management of renal dysfunction  
293 compared to the boiled and roasted extracts.

294 Packed cell volume (PCV), white blood cells (WBC), Platelet, Red Blood Cell (RBC) and HB are of  
295 diagnostic importance. A decrease PCV generally means red blood cell loss from cell destruction,  
296 blood loss or failure of bone marrow production. Consumption of plantain could protect the red  
297 blood cells due to its content of blood forming nutrients such as iron. This explains why the PCV of  
298 the diabetic control and non-diabetic control (table 6) is significantly different from the diabetic  
299 treated. Distinctly, the boiled and dried extracts have higher PCV values.

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301

302

303 **CONCLUSION** 

304 The knowledge of an effective processing method for dietary staples to control and ameliorate the  
 305 effect of complications of diabetes is essential in the treatment of diabetes. The findings in this study  
 306 are useful to health care providers and nutritionist in diabetes education. This is because diet  
 307 management is crucial to control spikes in blood glucose levels. The study indicates that unripe  
 308 plantain can be used in the management of complications arising from diabetes mellitus. The boiled  
 309 plantain extract had the highest hypoglycemic effect of all the processed test extracts and can be  
 310 used to decrease the effect of hyperglycemia. It can be used to improve the aberrations of the  
 311 enzymes activities of diabetes mellitus, whereas, the dried plantain extract has the highest TG and  
 312 LDL-cholesterol lowering effect and can effectively be used to manage the heart damaging effect of  
 313 diabetes mellitus. The use of dried plantain in the dietary management of diabetes mellitus could be  
 314 a breakthrough in the search of plants that could prevent the development of diabetic nephropathy.

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